Nancy Grace Roman Technology Fellowship

PISCES: An Integral Field Spectrograph to Advance High Contrast Imaging Technologies

Completed Technology Project (2013 - 2017)

Project Introduction

This is a proposal to build a novel optical integral field spectrograph (IFS) called the Prototype Imaging Spectrograph for Coronagraphic Exoplanet Studies (PISCES) for use with the NASA Exoplanet Exploration Program's High Contrast Imaging Testbed (HCIT) facility at JPL. Integral field spectroscopy is ideal for high contrast imaging, because in addition to spectral characterization of exoplanet atmospheres, the data products sample chromatic speckles created by imperfections in the telescope and starlight suppression system. It is of paramount importance to correct for these imperfections using focal plane wavefront sensing techniques. However, no IFS has met the challenging performance requirements of a direct imaging of Earth-like exoplanets mission. PISCES will demonstrate the ability for IFSs to operate in the high contrast imaging (contrast ~10^-9) regime, and the instrument concept proposed here represents a viable design for a flight-like instrument targeting exoplanet spectroscopy with direct imaging. This research program would raise the TRL of this high contrast IFS from 3 to 5. During the Roman Technology Fellowship Concept Study, we explored the PISCES design details and carried out trade studies. We defined the instrument requirements, developed a baseline design for PISCES, simulated its performance, created an innovative high contrast lenslet design to mitigate spectral crosstalk, experimentally verified our simulator, prepared the vacuum compatible opto-mechanical design, and estimated the cost of this instrument. We propose to build this PISCES design in the Development Effort in order to further advance the technological readiness of this instrument type. PISCES would be assembled and tested at Goddard, and subsequently delivered and integrated into the HCIT facility. The HCIT will be used to verify the PISCES instrument performance, which will validate the PISCES model, and thereby advance the TRL of this system. After demonstrating the performance, PISCES will be used to advance other critical high contrast technologies inside the HCIT. Current laboratory testing of internal coronagraphs use adaptive optics to compensate for aberrations introduced by the optical assembly. While deep contrasts (planet to star contrasts of ~10^-9) have been achieved in very narrow bandpasses (~1%), experimental tests at broader bandpasses have been unable to reach similar contrasts. Expanding high contrast over a broad bandpass is a core objective of the Exoplanet Exploration Program's Technology Plan. PISCES will be used as a facility class instrument to characterize the chromaticity of coronagraphs and their achieved wavefront solutions, towards the goal of isolating and rectifying the sources of bandwidth limitations. The instrument and calibration procedures will be made available to other HCIT users, stimulating the development and assessment of all internal coronagraph types being studied in NASA's New Worlds Technology Program. In addition to their unique value for imaging in high contrast scenes, IFSs have broad utility for characterizing emission line regions in a variety of astrophysical settings (e.g., AGN dynamical masses, globular clusters, supernovae, extragalactic star clusters, gamma ray bursts, and galaxies at various epochs). The development of PISCES is directly relevant to the

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

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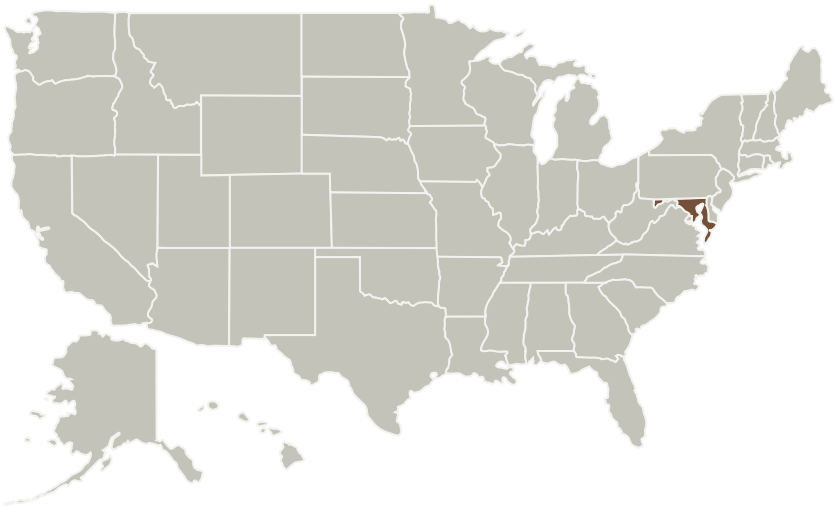
WFIRST AFTA mission, which has baselined IFSs for both dark energy and coronagraphic science. By supporting the development of PISCES, the Roman Fellowship Program will 1) advance the technical readiness of a key instrument envisioned for both WFIRST and a future New Worlds imaging mission and 2) provide me with valuable experience towards my career goal of leading a flight instrument for a major space observatory.

Primary U.S. Work Locations and Key Partners



Primary U.S. Work Locations
Maryland

Project Management

Program Director:

Mario R Perez

Program Manager:

Mario R Perez

Principal Investigator:

Michael W Mcelwain

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

Target Destination

Outside the Solar System